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Comparative Analysis of LGSF-Ferrocement Composite Construction Technology As a Sustainable Alternative to RCC: A Case Study

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ABSTRACT: - In the quest for sustainable construction methodologies, this study undertakes a comprehensive comparative analysis of Light Gauge Steel Frame (LGSF) combined with Ferrocement composite technology as an alternative to traditional Reinforced Cement Concrete (RCC). The research investigates the structural, environmental, and economic aspects of these construction techniques to ascertain their viability in contemporary building practices. A study encompasses an in-depth examination of the structural integrity and load-bearing capabilities of LGSF-Ferrocement composites, evaluating their performance under various conditions and stress factors. Additionally, environmental impact assessments are conducted, considering factors such as material production, energy consumption, and waste generation, to gauge the ecological sustainability of each construction method. Findings of this research aim to contribute valuable insights to the construction industry, policy-makers, and sustainability advocates. By offering a comprehensive comparative analysis, the study seeks to empower decision-makers in making informed choices about adopting LGSF-Ferrocement composite technology as a sustainable alternative to RCC in contemporary construction projects.

Keywords: -Light gauge steel frame (LGSF), Reinforced cement concrete (RCC), Ferrocement, Sustainability, Economic, Composites

1. INTRODUCTION

This study embarks on a thorough investigation into the Comparative Analysis of LGSF-Ferrocement Composite Construction Technology as a Sustainable Alternative to RCC. The motivation behind this research is to find a durable structures with a commitment to minimizing environmental footprints and optimizing economic efficiencies. The traditional use of RCC, while undeniably effective, is often associated with high energy consumption during production, substantial carbon emissions, and resource-intensive practices. In contrast, LGSF-Ferrocement composites represent a compelling alternative that has garnered attention for its potential to mitigate these concerns. The amalgamation of light gauge steel, known for its strength and versatility, with the durability and flexibility of ferrocement, presents a promising synergy that could redefine the standards of contemporary construction. As we delve into this comparative analysis, our objectives extend beyond structural considerations. We aim to explore the broader dimensions of sustainability, encompassing environmental impact and economic viability. By examining the holistic implications of adopting LGSF-Ferrocement composite technology, we aspire to provide a nuanced understanding of its potential as a sustainable alternative to RCC in the construction industry. Through this exploration, we seek to contribute to the discourse on sustainable construction practices, providing stakeholders with valuable insights that can inform decision-making processes. The forthcoming sections of this research will delve into the structural attributes, environmental implications, and economic considerations surrounding LGSF-Ferrocement composite construction, ultimately shedding light on its potential as a viable and sustainable alternative to the conventional RCC paradigm.

2. LITERATURE REVIEW

1. **Shivani Shinde, Pravin Minde, Mrudula Kulkarni** in their thesis "Analysis of LGSF-Ferrocement composite construction technology as a cost-effective & sustainable alternative to RCC" it is observed that in LGSF-Ferrocement composite technology, reduced weight of structural elements would ease the handling, transportation, and erection at the site. This has a significant impact on construction scheduling and time. In this type of construction predictable scheduling can be planned better than off-site construction. The reduction in deadweight ensures a reduction in lateral inertial force in the event of earthquake. As LGSF-Ferrocement form eliminates brickwork, a substantial saving in cement is anticipated and is reflected in material quantity for RCC and Composite buildings. Substantial reduction in curing bound and chemically bound water, cement, and steel makes this form sustainable than RCC. LGSF and

ferrocement panels are manufactured in the factory which gives better quality assurance. It is durable and has low maintenance. The LGSF used for construction is recyclable. Due to low material usage and reduction in CO2 emission, it is seen that this type of construction is ecofriendly and sustainable. The reduction in dead load which translated to reduction in base shear will give large savings in structural members resisting seismic forces. This type of structures has higher resistance to sound and fire also. It is observed that LGSF-Ferrocement composites structures are safe.

2. **Alia O. M. Ahmed & Nigel d. P. Barltrop etal.** in this review paper "Review paper on LGSF building and conventional building" they have discussed the LGSF structure's seismic performance in this study. These constructions function very well when subjected to seismic stresses. When designing a building's construction, seismic pressures and earthquakes are major considerations. Due to their ductility, lateral loading-prone steel frames may be constructed without the need of shear panels by employing portal framing, which will allow the results to be proven. Another investigation is conducted about the choice of steel components and cold formed steel.

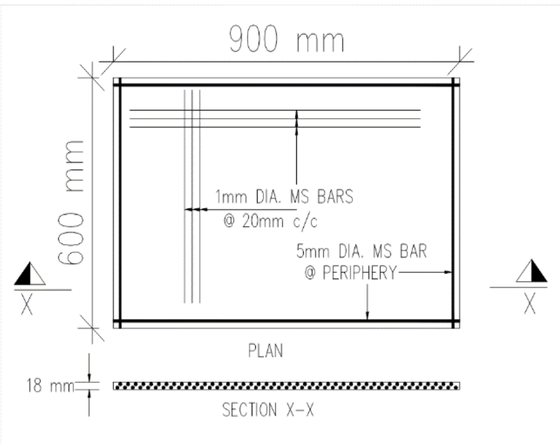
3. **V Venkatesan and R Ganesan** in the case study "A General Study of Light Gauge Steel Building" they have shown many statistical data by taking a case study of LGSF structure. The most significant advantages are the lack of need to using thermal operations, lack of thermal tensions of residual in sections, the possibility of creating sections in various shapes to achieve the maximum resistive return in section, lightweight, high resistance and rigidity, high accuracy in implementing details, and rapid and easy installation. It was investigated the torsional strength of lipped and without lipped channel sections were designed strength of depth and stiffness of the beam are increased. Failure of the entire beam was occurred by local buckling of the top flange. Both theoretical and numerical can be obtained in their angle of twisted. Physical properties and fabrication process of back-to-back channel section to be determined.

4. **Sumit Ruhil and Virender Rana** in their review paper "Review paper on LGSF building and Conventional building" they have shown There is virtually little cost difference between LGSF and RCC. LGSF is more expensive than RCC for small structures or buildings, but for mass level construction, the total cost is always lower than RCC. Depending on the project's size. LGSF components are manufactured in a facility and delivered directly to the site, eliminating the requirement for on-site material procurement. 5–10% of materials are wasted on building sites, however by employing these precast pieces, we can save costs and waste. Since all steel is recyclable, LGSF may be regarded as a sustainable material. Unlike RCC and brick structures, LGSF offers better thermal performance thanks to the cavity between the wall panels. LGSF construction is quicker than RCC since 90% of the components are precast; all that is left to do is assemble them on site. Despite all its advantages, LGSF has certain disadvantages, such as its societal influence on Indians who may not be psychologically ready to use it. LGSF is a good choice for commercial and storage space since it can be created quickly off-site and can adapt to future modifications without creating non-hazardous or non-recyclable trash. As a result, we may see it as a sustainable strategy to meet the building industry's future need.

3. MATERIAL AND SPECIFICATIONS

(a). Factory cast Ferrocement panels

Ferrocement is composed of cement mortar reinforced with small diameter closely spaced steel wire mesh to form a thin section conforming high performance of serviceability. The cement of choice is the normal Portland cement of 53 grades, as Pozzolana cement is not preferred due to the necessity of early strength in the mortar. The mortar gradations are as follows: Sand of a gradation of zone II and Fine aggregate in zone II and IV is used as it is best suited for structural mortars. The Ferrocement panel used for construction measures 600 mm X 900 mm X 18 mm thick. The expected strength of the Ferron panel is 70 MPa. The weld mesh in panels has a diameter of wires ranging from 1 mm to 1.5 mm, with the distance between wires measuring 15 mm to 25 mm. These panels are of very dense mortar and exhibit only 3.5% - 8% water absorption. The reinforcement details of Ferrocement panels are given in fig.1



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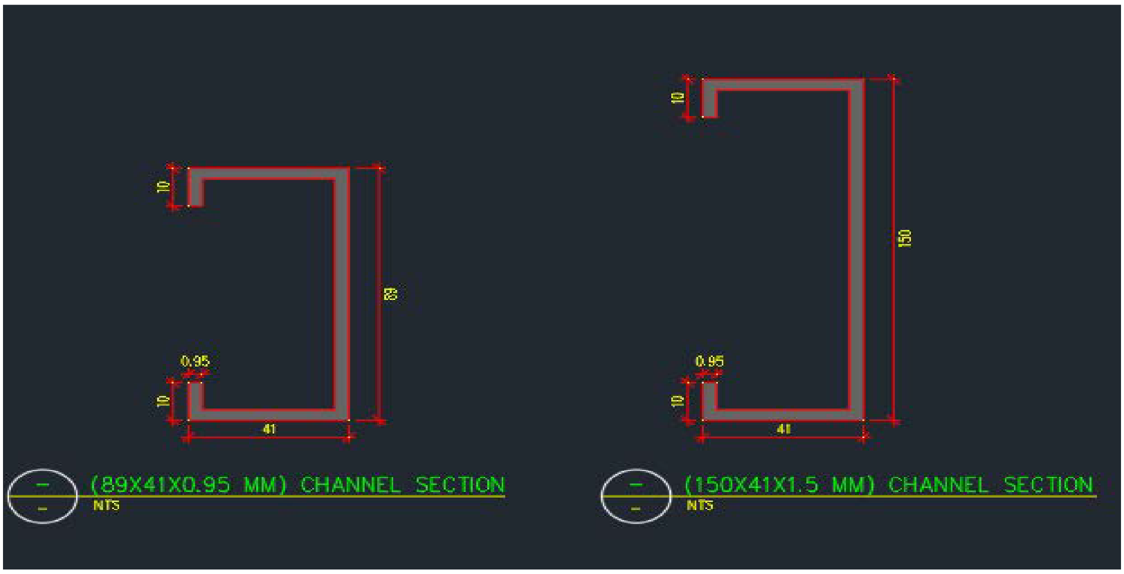
(b). Light Gauge Steel (LGS)

Light gauge steel framing systems consist of studs, noggins, and joists made from cold-formed steel, which is shaped by bending or pressing thin sheets of steel. LGS sections are manufactured by steel rolling mills as very thin rolled plates from which bent sections are made. The steel used here is coated with zinc (called galvanized) or a mixture of zinc and aluminum (called zincalume or galvalume by some) to protect it from corrosion. The thickness of the LGS section used in the given construction is 89mm X 41mm X 0.95mm and 150mm X 41mm X 1.15mm which has a strength of 550 MPa. There is an Indian code for the LGS steel material covered by IS-801–1975.



(c). Crackfill and Tapping screws

It is a cement base polymer modified powder material for filling cracks in plastered surfaces. It is ideal to fill 10 to 12 mm wider static cracks, it has strong adhesion and also non-shrink in nature. A screw with a low height, rounded head with a flat bottom having a market size 10/16 mm is been used for the connection of LGS frames (connection between studs, noggins). A self-tapping screw of market size 8/38 mm used for the connection of ferrocement panels and LGS frames.

10/16mm Pan-headed tapping Screw
Used for Connection of LGS frames

8/38mm Tapping Screw
Used for Connection of Panels and LGS frames

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4. CONSTRUCTION PROCEDURE

Site Clearance & Erection of MS Columns, Beams

↓

Fixing of Joist member & Ferron panel for Slab

↓

Laying of Concrete on slab

↓

Assembling and erection of LGS Frame

↓

Fixing of interior and exterior Ferron panels

↓

Fixing of Electrical lines and Plumbing lines

↓

Waterproofing of WC, bath and Terrace

↓

Finishing work

Fig. 1. Erection of MS Columns, Beams

Fig. 2. Fixing of Joist member for Slab

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Fig. 3. Fixing of Ferron panels

Fig. 4. Erection of LGS Frames

Fig. 5. Fixing of Ferron panels for walls

Fig. 6. Finishing Work

5. CASE STUDY

It is worth checking and comparing the merits of LGSF-Ferrocement composite construction over traditional RCC construction. Fig. 1 to Fig. 6 present the fifth floor of RCC building. A detail study was done for the extension of one floor whether in the conventional work i.e. RCC or in composite structure of LGSF and ferrocement technique.

4.1. Analysis of time by MS EXCEL

Planning for the extension of the floor using LGSF-Ferrocement composite technology and conventional RCC method was conducted using MICROSOFT EXCEL. Figures 7 and 8 illustrate the MS EXCEL planning for the building by LGSF-Ferrocement composite technology and conventional RCC method, respectively. Following planning and scheduling in MS EXCEL, the time needed to complete construction using LGS-ferrocement technology is determined to be 40 days, while the conventional RCC method requires 120 days, as depicted in Figure 8. It is evident that both the number of activities and the time required for completion of the building using LGSF-Ferrocement technology are less than those for the conventional RCC method. Through time analysis, it is observed that the time required for LGSF-Ferrocement composite construction is reduced by 66.67% compared to conventional RCC construction.

4.2. Analysis of construction cost

The cost of construction (excluding finishing) was calculated for both the conventional RCC method and LGS-ferrocement composite construction. For the conventional RCC method, the cost amounted to Rs. 2,651,302 while for LGSF-Ferrocement composite construction, it was Rs. 3,334,500. The elimination of brickwork in LGSF-Ferrocement composite structures leads to substantial savings in cement, crush sand, M-sand for plastering and mainly plenty of water. Additionally, fewer laborers are required, and erection can be accomplished without the need for sophisticated equipment, resulting in reduced time compared to the conventional RCC method. Figure 9 illustrates the cost comparison between RCC and LGSF-Ferrocement.

Through cost analysis, it is observed that the cost of LGSF-Ferrocement composite construction is slightly higher by 30% compared to conventional RCC construction.

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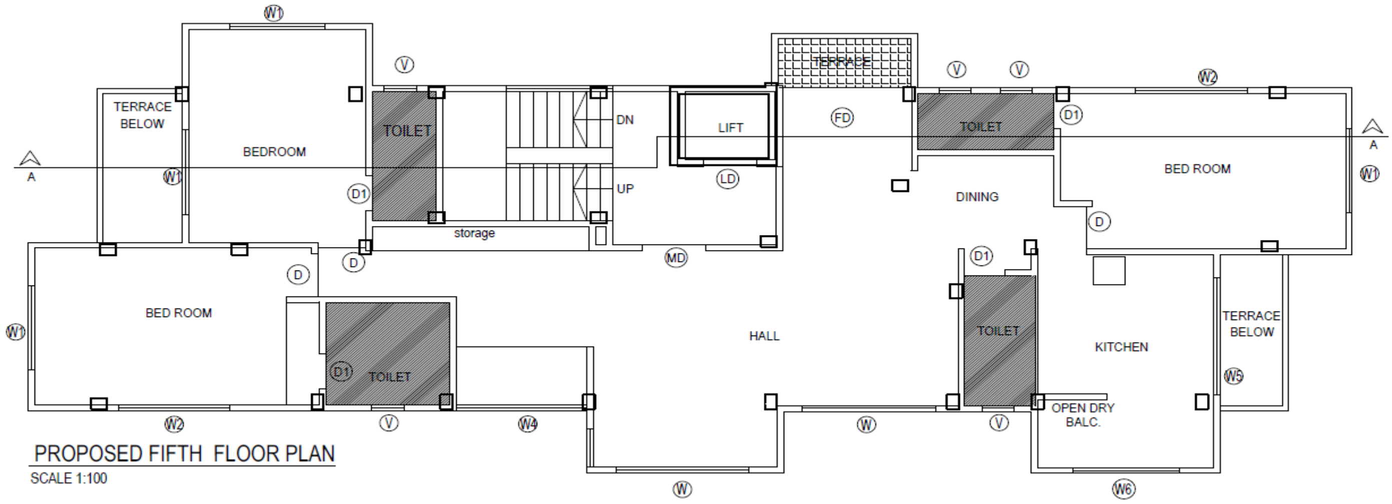

Fig. 6. Proposed floor Plan

6. RESULT AND DISCUSSION

The present study highlights the advantages of LGSF-Ferrocement composite technology, particularly in terms of handling, transportation, and erection due to the reduced weight of structural elements. This not only impacts construction scheduling and cost but also ensures a more predictable timetable compared to off-site construction, as it is unaffected by weather conditions. Additionally, the elimination of brickwork in LGSF ferrocement leads to significant savings in cement, making it a more sustainable and cost-effective option compared to RCC. The manufacturing of LGSF and ferrocement panels in factories also enhances quality assurance, ensuring durability and low maintenance for these structures. Moreover, the recyclability of LGSF used in construction, along with reduced material usage and CO_2 emissions, emphasizes the eco-friendliness and sustainability of this construction method. Furthermore, the reduction in dead load contributes to savings in structural members resisting seismic forces, while providing higher resistance to sound and fire. Overall, the numerous benefits of LGSF-ferrocement composite technology position it as a promising alternative to RCC construction for the future.

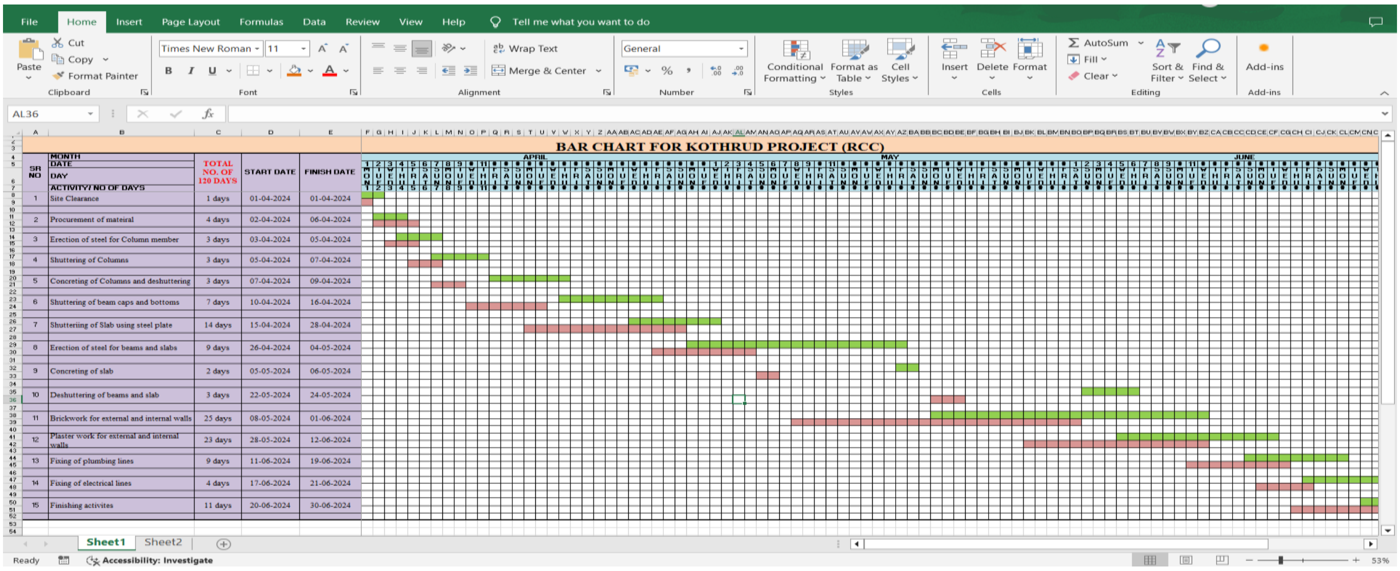

Fig. 7. Analysis of Time in RCC structure using MS EXCEL.

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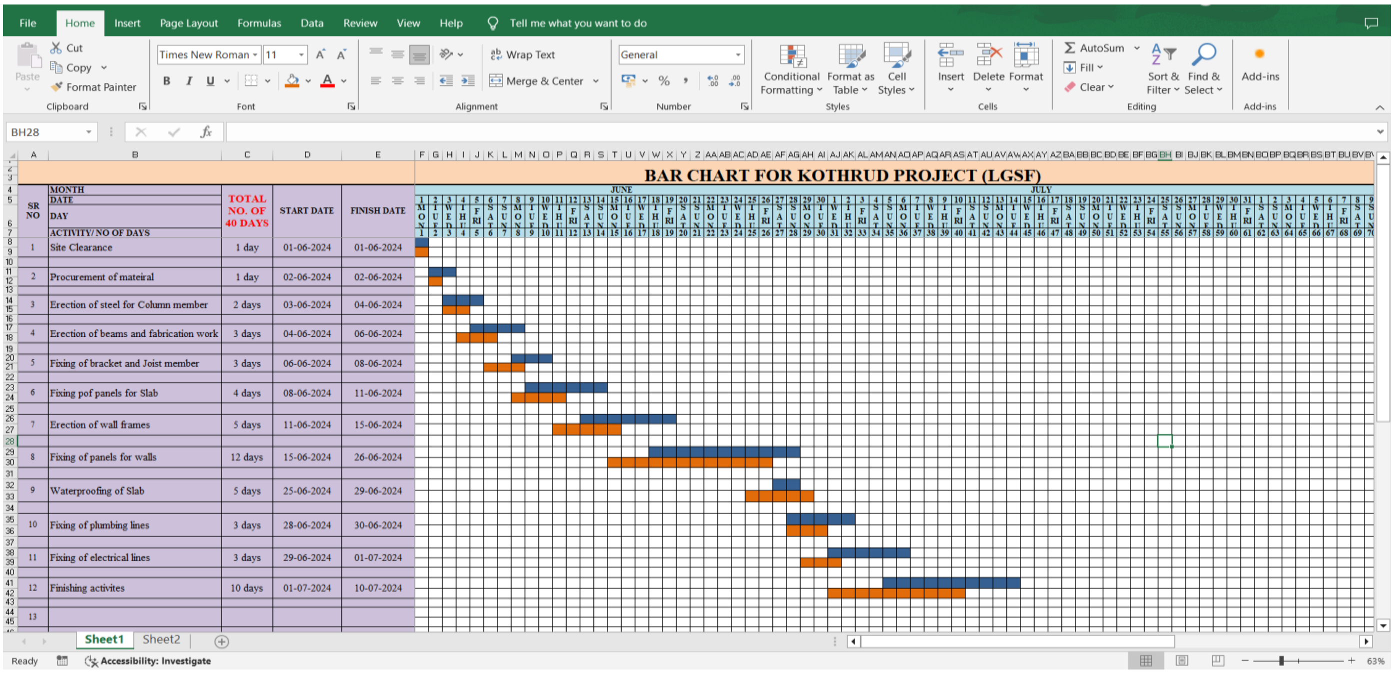

Fig. 8. Analysis of Time in LGSF structure using MS EXCEL.

7. CONCLUSION

Fig. 9. Cost Comparison of RCC and LGS-Ferrocement.

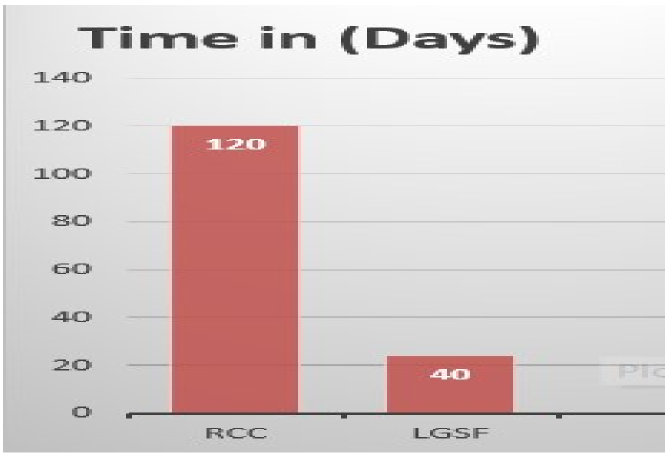

Fig. 10. Time Comparison of RCC and LGS-Ferrocement.

The present work concludes that the LGSF-Ferrocement composite construction offers significant advantages over traditional RCC construction. The composite structure of LGSF-Ferrocement reduces the deadweight of the structure by approximately 60%. The total consumption of steel in LGSF-Ferrocement technique is slightly higher in comparison with RCC work i.e. by 20-25% but it also completely eliminates the need for brickwork. Additionally, the use of cement and water is significantly reduced, allowing for a 15–20% cost reduction compared to conventional RCC methods. With proper planning and management, construction time can be reduced by 65-70%. In summary, LGSF-Ferrocement composite construction is a lightweight, seismically advantageous, and sustainable alternative to RCC.

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